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ESCALANTE STATE PARK - GEOLOGIC TRAIL GUIDE, UTAH

S.K. Morgan, B. Lindsay, and A. Hoffman
Utah State University
Logan, Utah

INTRODUCTION

The Escalante State Park geologic trail guide supplements the existing nature trail guide making use of the posted markers as geologic points of interest. The trail is a loop and is approximately one mile long. A side excursion, the Trail of Sleeping Rainbows, is approximately three quarters of a mile long and is accessed from the main route. The geologic trail guide describes the stratigraphy or layers of rock that are exposed along the trail and at scenic view points. In addition, geologic phenomena that create the scenery along the trail and the petrified wood are discussed. The walk can be very hot and dry in the summer. Please bring plenty of water and enjoy your hike.

SIGN POST 1 - TIDWELL MEMBER OF THE MORRISON FORMATION

The trail begins by leading up through a red slope eroded from the Upper Jurassic Tidwell Member of the Morrison Formation (figure 1). These beds have been previously mapped as the Summerville Formation. The Tidwell consists of alternating beds of red to green siltstone and mudstone and green-gray sandstone. The red siltstone/mudstone weathers easily and slurries over the green-gray layers coloring them red and making them hard to distinguish from a distance.

The Tidwell derives its red and green colors from small amounts of iron contained in the sediment. Reduced iron gives the siltstone and sandstone its green coloration whereas oxidized iron turns the rocks red.

The Tidwell Member represents river deposition sourced from nearby highlands in the Late Jurassic. Sediment-choked streams drained the uplifted regions, transporting and depositing material to the newly created foreland basin in central and eastern Utah (Robinson and McCabe, 1998). Mudstone and siltstone were deposited on broad floodplains studded with occasional lakes and ponds whereas sporadic channel-point bar deposits were preserved as sandstone interbeds which typically occur as lenses that thin and eventually pinch out in both directions from a thick central point. Continuing along the trail you move into white to grey sandstone outcrops of the Salt Wash Member of the Upper Jurassic Morrison Formation.

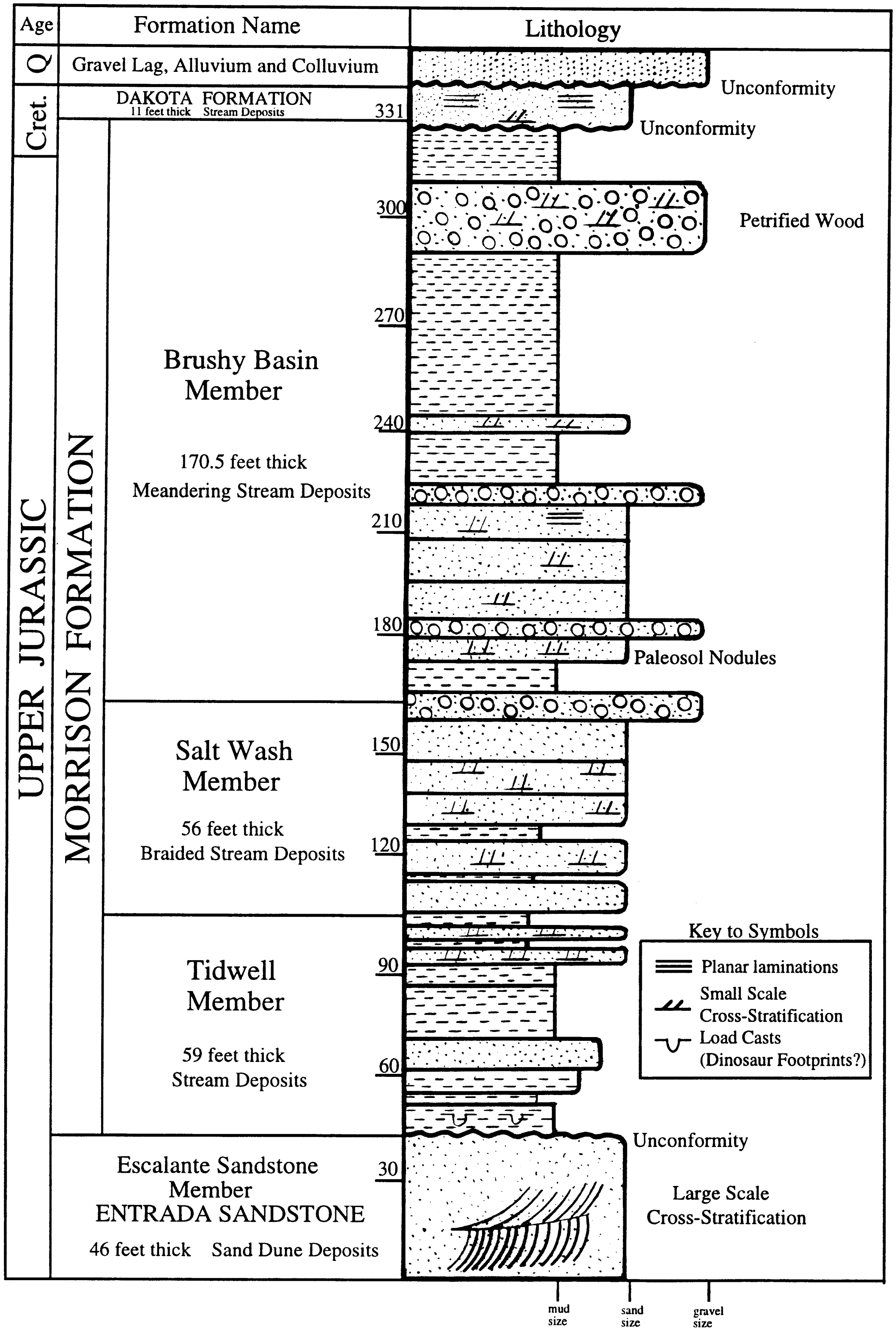

Figure 1. Stratigraphic column of rocks in the vicinity of Escalante State Park.

SIGN POST 2 - VIEWS AND PEDESTAL ROCK

As you look over the campground to the northwest, there is an excellent view of the stratigraphy or vertical sequence of rock exposed in Escalante State Park (figure 2). The lowest layer, the white Upper Jurassic Escalante Member of the Entrada Sandstone, crops out along the far edge of the campground. The white Escalante sandstone is overlain by the red, distinctly layered lower Tidwell Member of the Upper Jurassic Morrison Formation that is in turn covered by the multicolored mud slopes of the upper Brushy Basin Member of the Morrison Formation. The Morrison is topped with the Cretaceous Cedar Mountain Formation composed of a lower yellow to dark-brown conglomerate and an upper gray mudstone.

This vertical sequence of rocks holds a story of changing depositional environments, geographic locations where the sediment accumulated millions and millions of years ago. The oldest and lowest rock, the Escalante Sandstone, accumulated during the late middle Jurassic as coastal winds sculptured thick accumulations of loose sand into sand dunes, exposed today as the white Escalante Sandstone. The dunes gave way to river deposits of the Tidwell Member, sourced from newly forming highlands westward in Nevada, Utah and California and southward in Arizona (Young, 1987; Peterson, 1988a; Peterson, 1988b). Continued uplift of the highlands provided coarsening clastic sediments, forming the Salt Wash Member, eroded from exposed Paleozoic and Mesozoic rocks (Robinson and McCabe, 1998). The braided streams of the Salt Wash were gradually replaced by migrating river channel sandstone and conglomerate and increasing floodplain and lacustrine (lake) mudstone of the Brushy Basin Member (Johnson, 1988; Peterson, 1988a). In the Early Cretaceous, rising sea level resulted in deposition of the overlying Dakota Formation.

In the distance the regional stratigraphy is exposed in cliffs that rise to the west and southwest across Wide Hollow Reservoir. Directly west of the reservoir exposures of the park stratigraphy are repeated with some variation: the lowest Escalante Member of the Entrada Sandstone overlain by the red sandstone and multicolored mudstone of the Morrison Formation, and yellow to brown sandstone and conglomerate of the Dakota Formation. Above the Dakota are the black slope-forming Cretaceous Tropic Shale and yellow sandstone cliffs of the Cretaceous Straight Cliffs Formation (Peterson, 1971; Stephens, 1973).

The farthest cliffs in the distance flank the Table Mountain Plateau and expose the Early Tertiary Claron Formation. Erosion of the formation has produced many interesting weathering features, tall spires called hoodoos, as seen in Bryce National Park and Cedar Breaks National Monument.

The **pedestal rock** is also created by weathering phenomena. The large boulder fell from the overlying cliffs and is a sandstone and conglomerate from the overlying conglomeratic layer in the upper Brushy Basin Member of the Morrison Formation. Once the boulder came to rest on the sandstone and mudstone of the Salt Wash Member of the Morrison Formation, wind and water began to weather away the softer underlying material leaving only a pedestal to hold the more resistant boulder in its place.

From this stop the trail continues over exposures of white sandstone and red mudstone of the Salt Wash Member.

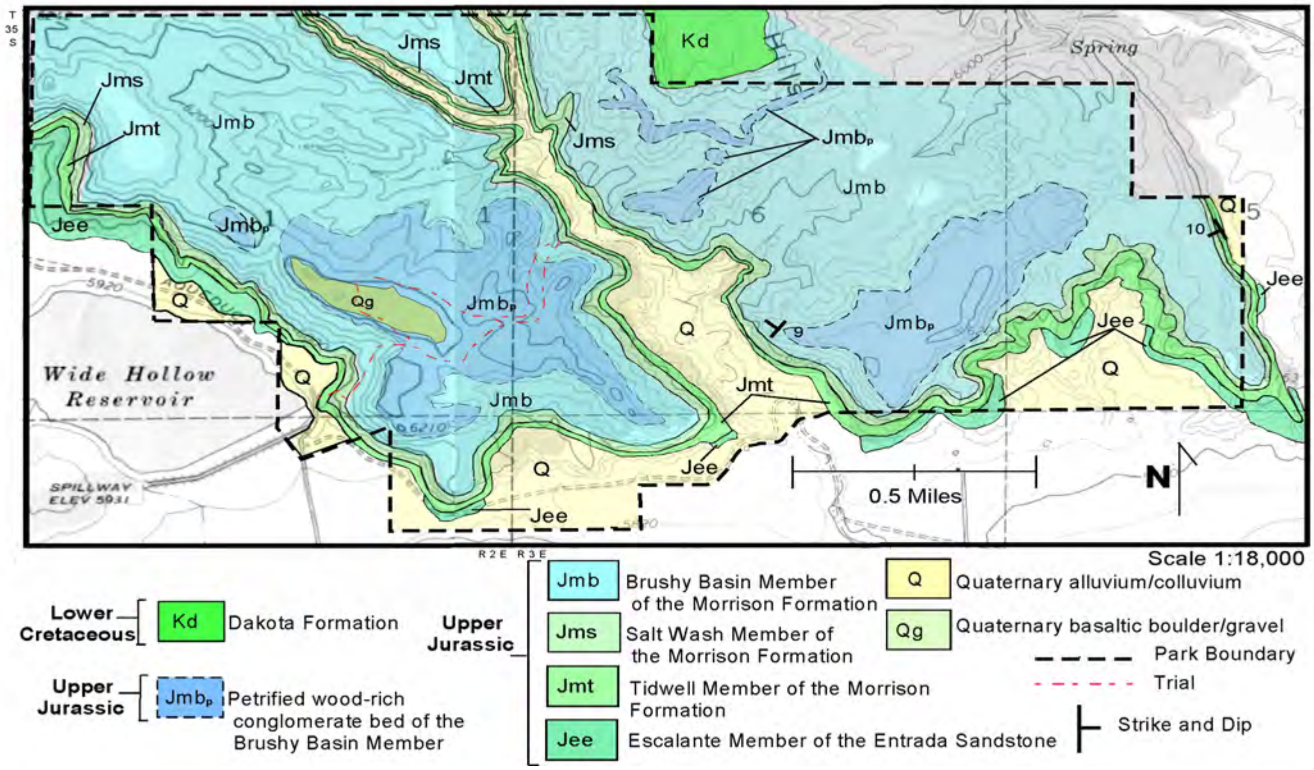

Figure 2. Geologic map of Escalante State Park.

SIGN POST 3 - ROCKS, FALLING BOULDERS AND DESERT VARNISH

Examples of Jurassic-age rocks are visible from this locality. The boulder on the side of the path fell from the cliffs above. It is composed of sandstone and conglomerate of the Jurassic upper Brushy Basin Member and was most likely deposited by braided streams.

The dark patina on the boulder is the result of desert varnish, a thin surface-coating that occurs over rocks in arid climates. One explanation for desert varnish is that it is formed by microscopic bacteria that live on the rock surface. The bacteria absorb minute amounts of manganese, iron and clay from the atmosphere and redeposit them on the rock surface creating the dark-colored patina. Another explanation is that desert varnish is a result of weathering processes. Iron, magnesium, and other trace elements in solution may be transported either by rain or dew and deposited on the surface of rock. Desert varnish can be many different colors, but is most commonly black or red.

SIGN POST 4 -VIEW OF REGIONAL GEOLOGY

A spectacular view of the regional geology unfolds before you. The slight southwestern to western regional dip of the layers or strata is apparent. The rocks in the distance are no longer completely horizontal as originally deposited but have been warped and folded slightly through time. The volcanic rocks basalt, basaltic andesite and rhyolite form the black-looking cap of the Table Top and Aquarius plateaus in the distance (Peterson, 1971; Hintze, 1988). These igneous rocks are remnants from a time when the region was volcanically active between 38 to 12 million years ago in the Tertiary. Over 10 million years later in the Pleistocene, as a result of cooler global temperatures, glaciers formed in the high plateaus and mountains that you see in the distance. As little as 10,000 years ago glaciers were still scouring bedrock and moving loose rock debris from the hillsides. As the glaciers receded, melt-water streams and possibly debris flows, a mass wasting event, transported numerous black boulders great distances form their source (Smith and others, 1963).

SIGN POST 5 - MOVING BOULDERS
Look above this large lichen-covered boulder and notice many other boulders dot the slope. They are moving downhill by a process called rock creep. Inflation and deflation of the slope caused by the slow process of freeze and thaw and wetting and drying cycles alternately raise and lower the boulders slightly (Easterbrook, 1993). When the boulders settle back as the slope deflates they move slightly down hill under the influence of gravity.

SIGN POST 6 - SALT WASH MEMBER OF THE MORRISON FORMATION
The clasts in the sandy to conglomeratic rock of the Salt Wash exposed in and along the trail are arranged in slopping thin layers, referred to as cross-stratification, a type of sedimentary structure. Sedimentary structures occur in sedimentary rocks and are distinctive arrangements of grains that reflect the environment of deposition of the sediment. Cross-stratification occurs when particles carried by a moving current such as water or wind are dropped and deposited (Boggs, 1995). The orientation of the sloping cross-stratification yields information about the direction the ancient current was moving. This feature can be seen both in fluvial or stream-deposited rocks and eolian or wind-deposited rocks.

The smaller scale, one meter or less high, cross-stratification of sandstone and conglomerate of the Salt Wash Member resulted from deposition in a stream environment (Allison, 1997). An excellent example of large scale, greater than one meter high, eolian cross-stratified rocks is exposed in the white sandstone of the Escalante Member of the Entrada Sandstone that crops out in the park campground.

SIGN POST 7 - BRUSHY BASIN COLORS
Colorful mudrock of the Brushy Basin Member of the Morrison Formation is exposed along this section of trail. The lower mudrock layers are red to maroon whereas the upper mudrock is white to green and grey. Most of mudrock contains smectite, a clay that forms as a result of alteration of originally deposited volcanic ash. When the Morrison was forming, volcanoes west of Utah erupted violently spewing ash into the air that became incorporated in the accumulating Morrison mud. The volcanic material tells a story of Jurassic plate tectonics. Volcanoes were created when magma formed as a result of subduction of oceanic crust underneath the continental crust of the western margin of the North American plate (Hintze, 1988). Small amounts of various elements and minerals in the ash have tinged the mudrock shades of orange, red, purple and green.

SIGN POST 8 - TRAIL JUNCTION AND CONGLOMERATE
Outcrops of cross-stratified conglomerate of the upper conglomeratic unit of the Brushy Basin Member of the Morrison Formation are exposed at the trail junction and along the trail. Conglomeratic rocks are composed of rounded particles of which 35 percent or more are greater than 2 mm in size. Here, particles are supported by a quartz cement and sand matrix. Many of the gravel particles or clasts that make up the conglomerate are chert, however some are rock fragments and petrified wood. The gravel was

transported and deposited by braided streams in the late Jurassic. The gravel that covers a good part of the trail in this area comes from weathering of the conglomerate.

SIGN POST 9 - VIEW TO THE SOUTH
The town of Escalante lies within Escalante valley to the south. The valley is flanked on the west by the Straight Cliffs and the Kaiparowits Plateau. These escarpments expose layers of the Cretaceous-age Straight Cliffs Formation, Wahweap Sandstone, and Kaiparowits Formation. To the northeast, across Pine Creek Valley, the Lower Jurassic Navajo Sandstone is exposed in the steeply dipping west limb of the Escalante anticline. The originally horizontal sedimentary rocks were warped into the anticlinal fold during the late Cretaceous to early Tertiary Laramide orogeny, a compressional mountain-building event that produced several major folds in southern Utah (Hintze, 1988).

SIGN POST 10 - PETRIFIED WOOD
Large pieces of petrified wood preserved in the upper conglomeratic layer of the upper Brushy Basin Member of the Morrison Formation occur in this area. Much of the wood lies just as it did when it was deposited 130 to 140 million years ago when dinosaurs roamed the territory. The conglomeratic layers represent gravel and sand deposited by braided streams and contain large sections of petrified wood. Conifers living adjacent to large braided streams may have been uprooted and rolled along the stream bed until they finally came to rest with the accumulated channel gravel and sand. Although in many samples you can see the texture of the bark and sometimes even growth rings, the wood preservation is not good enough to identify the type of conifers (D.A. Medlyn, verbal communication, 1999).

SIGN POST 11 - SLEEPING RAINBOWS TRAIL: MORE PETRIFIED WOOD AND VIEWS WEST
The Sleeping Rainbows trail is a very steep trail but there are spectacular displays of petrified wood along the way. It is well worth the effort to see a variety of very brightly colored wood in a natural setting as it eroded out of the rock. Most of the wood probably eroded out of the overlying upper conglomerate of the Brushy Basin Member of the Morrison and tumbled down slope to rest on the lower variegated Brushy Basin mudstone.

Once you descend the trail to the bottom of the gully you overlook a pour-off into Baily Wash. The lowest cliff wall, on the opposite side of the wash, exposes red sandstone and mudrock layers of the Tidwell Member of the Morrison and is capped by the Salt Wash member of the Morrison Formation. Look closely and you will see a good exposure of a channel scour. During deposition of the Salt Wash Member, a river scoured a channel into the Tidwell that was later in filled with sand and gravel.

Slopes above the sandstone and conglomerate cliff are formed in the easily erodible mudrock of the Brushy Basin Member of the Morrison Formation. This is capped with the more resistant upper conglomerate unit within the Brushy Basin exposed in the close hillsides. The distant hillside to the northeast is topped with the Cretaceous Dakota Formation. The Dakota has three members that reflect changing depositional environments as the Cretaceous sea level fluctuated: a lower conglomerate and sandstone indicate deposition in a stream to nearshore beach environments, a middle black shale most likely deposited in estuarine to lagoonal environment, and an upper orange-yellow sandstone accumulated in an offshore marine environment (Young, 1973; Doelling and others, 1989).

As the trail begins back uphill, an interesting sandstone crops out along the trail in 1.5- to 3.5-foot-thick beds. The calcite-cemented sandstone is composed of numerous spherical nodules from 0.33 to 1 inch in diameter. The nodules mark a calcrete zone in soil horizon C of a paleosol, an ancient soil horizon that formed on the sandstone. Calcretes develop either as a precipitate from ground water supersaturated with calcium carbonate or from rain leaching calcium carbonate dust into the soil that was carried there by the wind (Machette, 1985; Retallack, 1997). Once exposed, millions of years later, the calcrete weathered into spherical, calcite-cemented sandstone nodules.

SIGN POST 12 - PETRIFIED WOOD

Petrification is a means of changing wood into rock and occurs as a process of replacement. As wood tissue begins to decay in the presence of water containing dissolved ions, the organic material is replaced by minerals. When this occurs slowly the microscopic structure of the wood is duplicated, however, when replacement is rapid the original wood structure is destroyed (Fenton and Fenton, 1989). If you look carefully you can see the texture of the bark on the outside of some of the petrified wood but the internal structure of growth rings is poorly preserved. The wood is replace by a variety of silica called agate that contains mineral impurities which impart the often spectacular colors.

SIGN POST 13 - BLACK BOULDERS

The trail is surrounded by dark-red to mostly black rocks ranging from boulders up to 3 feet in length to smaller cobbles and gravel. Although the bedrock in the park is sedimentary, these dark red and black rocks are igneous rhyolite and basalt. Igneous activity in the later Tertiary produced a several hundred-foot-thick cap of basalt and rhyolite on the Aquarius Plateau and Boulder Mountain to the north in the distance. Much later, glaciers covered these high regions as a result of a cooler climate. Glacier meltwater streams and debris flows transported the dark-red and black boulders, cobbles and gravel to their present resting place (Smith and others, 1963). During transport, the rocks knocked into each other rounding their corners and edges producing smooth rocks.

On close inspection, pits within the igneous rocks can be seen. Once erupted, the lava began to cool. Gas trapped within the semi-fluid lava made its way to the surface and escaped, leaving vesicles in the hardened rock.

Some of the boulders in this area have a partial white coating called caliche. Caliche is made of soluble calcium salts such as calcium carbonate that are dissolved from the soil and brought to the surface by rain or ground water. The calcium carbonate coating collects on the underside of the stones as the water evaporates, and can be seen when the stone is rolled over.

SIGN POST 14 - GROWTH RINGS AND COLORS

This is one of the largest diameter samples of wood found in the park and it displays exceptional color and preservation. It occurs in the upper mudstone floodplain or lake sediments of the upper Brushy Basin Member of the Morrison Formation. Trees living on the floodplains of meandering rivers or along lakes fell into the soft sediment where they were quickly buried and preserved. Due to slow replacement of the original wood structure by silica, the original texture of the bark and growth rings are visible in the cross section view of the trunk. Can you count the rings to determine the age of the tree when it died?

The colors seen in the park's petrified wood are a result of small amounts of elements or specific minerals contained within the quartz. Common elements and the colors they produce are: copper, cobalt and chromium all produce shades of green and blue; manganese tinges the rock pink; carbon and manganese cause black; and iron produces various shades of red, brown, yellow, and green.

Most of the wood in the park is broken into segments. The stress and strain of the moving tectonic plates fractured the rocks including the petrified wood. Once exposed, weathering caused the wood to separate along the fractures.

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